Chapter 15 Subgrade Design

This chapter describes a couple of procedures to create strings to create subgrade strings for a roadway. After subgrade strings have been created, and subgrade cross sections have been generated, you can obtain cut/fill volumes for the roadway.

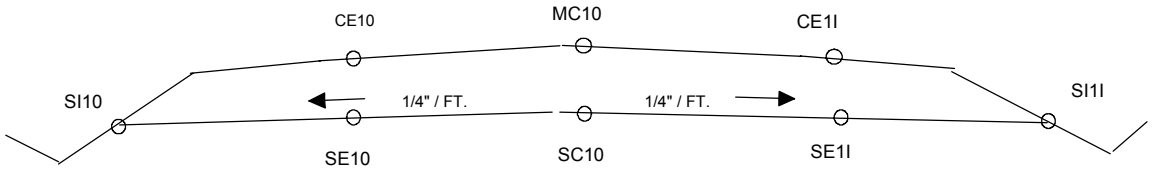
Two methods will be described in this chapter:

1. ***The Input File Method***
2. ***The Pavement And Subgrade Design Wizard***

Each of these methods has merit, and each has drawbacks. It's quite likely that the best approach for a given project may be to use a combination of both methods.

The Input File Method Of Creating Subgrade Strings

Create a model called SUBGRADE to contain the subgrade strings. If you have side roads, or multiple mainline alignments, you might want to consider keeping the subgrade strings for each alignment in a separate model. If so, then consider naming your subgrade models SUBGRADE MC10, SUBGRADE MCA1, etc. The Pavement and Subgrade Design Wizard uses a slightly different and automated naming convention. Refer to earlier steps in this manual for instructions on how to create a model, if necessary.



All subgrade string labels will begin with "S". The second character will indicate under which design template string the subgrade string is located. The third character will indicate which alignment the subgrade string is associated with, and the fourth character will designate which side of the master alignment the string is located on. Specific examples of the naming of subgrade strings will be shown in the next two sections of this chapter.

Subgrade Strings for Rural Highways / Ditch Sections

The illustration below shows the subgrade string labels for use with Mainline Master alignment MC10. This is a typical subgrade section for most of our rural highways where ditches are used.

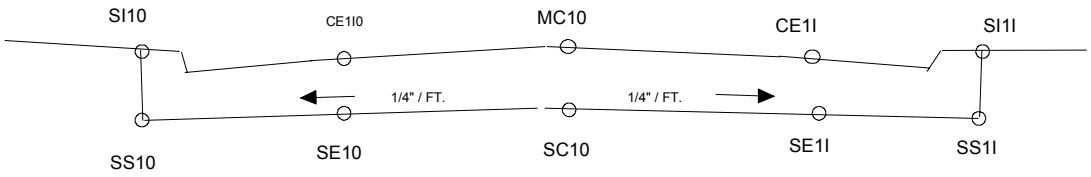
The three strings, SC10, SE10, and SE1I are created as feature strings using Major Option DESIGN. The other two strings, SI10 and SI1I, are created using Major Option INTERFACE. The following code will create these strings and put them into the SUBGRADE model:

```
DESIGN,DESIGN,SUBGRADE
110,MC10,,SC10,-2.5,,,0,
110,CE10,,SE10,-2.5,,,0,
110,CE1I,,SE1I,-2.5,,,0,
999

INTERFAC,DESIGN,SUBGRADE
260,SE10,SI10,,-1,,,,
261,AUTO,SE10,,3,7=-.02
263
260,SE1I,SI1I,,1,,,,
261,AUTO,SE1I,,3,7=-.02
263
999
```

The commands listed under Major Option DESIGN above will create subgrade strings directly below the Mainline M-String and edges of traveled way strings at a depth of 750mm.

The commands listed under Major Option INTERFAC will then create strings at the point



where a -2% gradient intercepts the Design Template's front slope. Each side is interfaced separately, since two different strings are being created.

In those areas where the Design Template is superelevated, the "low side" gradient will likely be greater than a -2% gradient. The INTERFAC portion of this file would need to be broken out into separate sections to specify the area of maximum superelevation, as well as the transition areas.

Subgrade Strings for Urban Highways / Box Sections

The creation of subgrade strings for box sections requires the generation of an additional string in the DESIGN section of the INPUT file. The figure below illustrates this situation:

The extra strings, SS11 and SS1I, are normally located 1 ft. behind the gutter line. The following lines of code will create these subgrade strings:

```
DESIGN,DESIGN,SUBGRADE
110,MC10,,SC10,-2.5,,,0,
110,CE10,,SE10,-2.5,,0,
110,CE1I,,SE1I,-2.5,,,0,
110,EF10,,SS10,-2.5,,,-1.0,
110,EF1I,,SS1I,-2.5,,,1.0,
999



INTERFAC,DESIGN,SUBGRADE
260,SS1I,SI1I,,1,,,,
261,AUTO,SS1I,,3,7=150
263
```

```
260,SS10,SI10,,-1,,,,
261,AUTO,SS10,,3,7=150
263
999
```

In the DESIGN portion of code above, the last two 110 cards show the subgrade strings SS10 and SS1I being created the same depth below the Design Template, but offset 0.3 meters behind the gutter lines.

The INTERFAC sections of code show the interfacing begins at subgrade strings SS10 and SS1I, then interfacing to the Design Model up at 150:1. These interface strings must be offset a bit so that the MX engine will be able to correctly determine the order of strings to cut when the SUBGRADE model is sectioned.

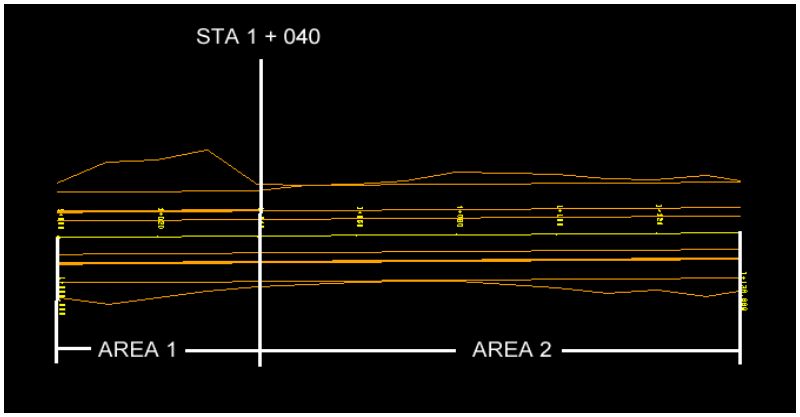
Pavement and Subgrade Design Wizard Method:

This wizard works quite nicely for creating a "day lighted" subgrade to a front slope, but in order to make this wizard produce box sections in accordance with MDOT's standard design criteria, be sure to provide an earthworks datum string (EH) as part of your design template at an offset of 1 ft. beyond your edge of shoulder or gutter line. This EH string is critical to properly define the subgrade strings with this wizard. If you used the MXRoad Shoulders, Curbs, and Sidewalks Wizard to create your curb strings, etc. and selected one of the custom MDOT templates for use in the Shoulders, Curbs, and Sidewalks wizard, this string was created unless you changed the standard template.

Step 1: Make sure the template and earthworks strings are complete, and then create cross sections at each point on your master alignment string. The wizard will not work unless a section exists at every point on your M-String. A second set of cross section wizard settings is a handy way to quickly switch from cutting a section at all points on an M-String, to a specified interval/skewed/special station group of sections for final plans.

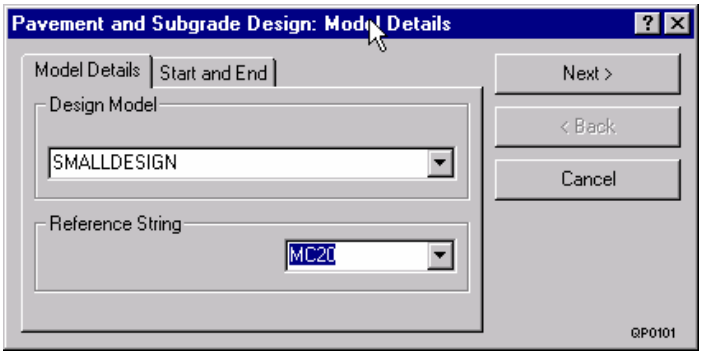
Step 2: Determine station-to-station limits of subgrade areas. Separate subgrade areas would be necessary for each area where a change in the control limit string occurs, or a change in the subgrade depth occurs. The following image shows the subgrade areas used for the training class example:

In Area 1, a curbed area, our subgrade control limit on the left is defined by an EH string, while in Area 2, a non-curbed area, the subgrade control limit switches to the edge of shoulder ES string. This requires the definition of two areas.



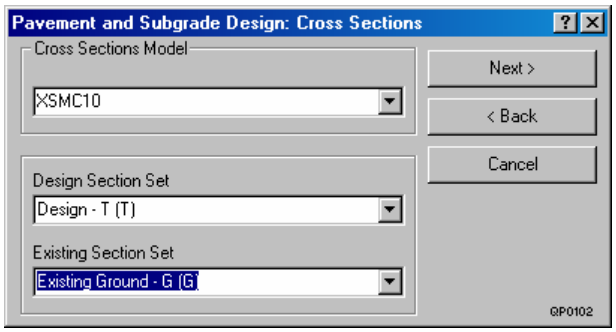
Step 3: Start the Pavement And Subgrade Design Wizard

Select **Design => Pavement and Subgrade Design** from the menu bar. The following panel will appear:

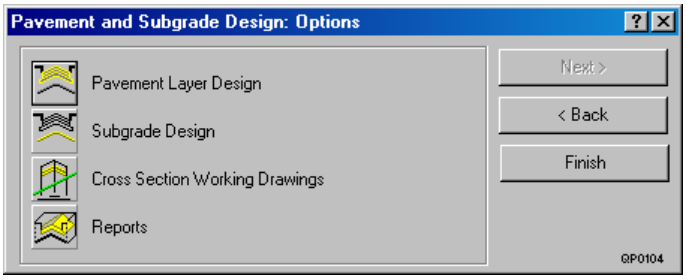


Pick the Design Model and Reference String (and station limits if desired), then click Next to continue.

Step 4: Select the model containing your cross sections, and specify the section set identifiers for the design template cross sections, and existing ground cross sections.



Click Next to continue. The following panel will appear:



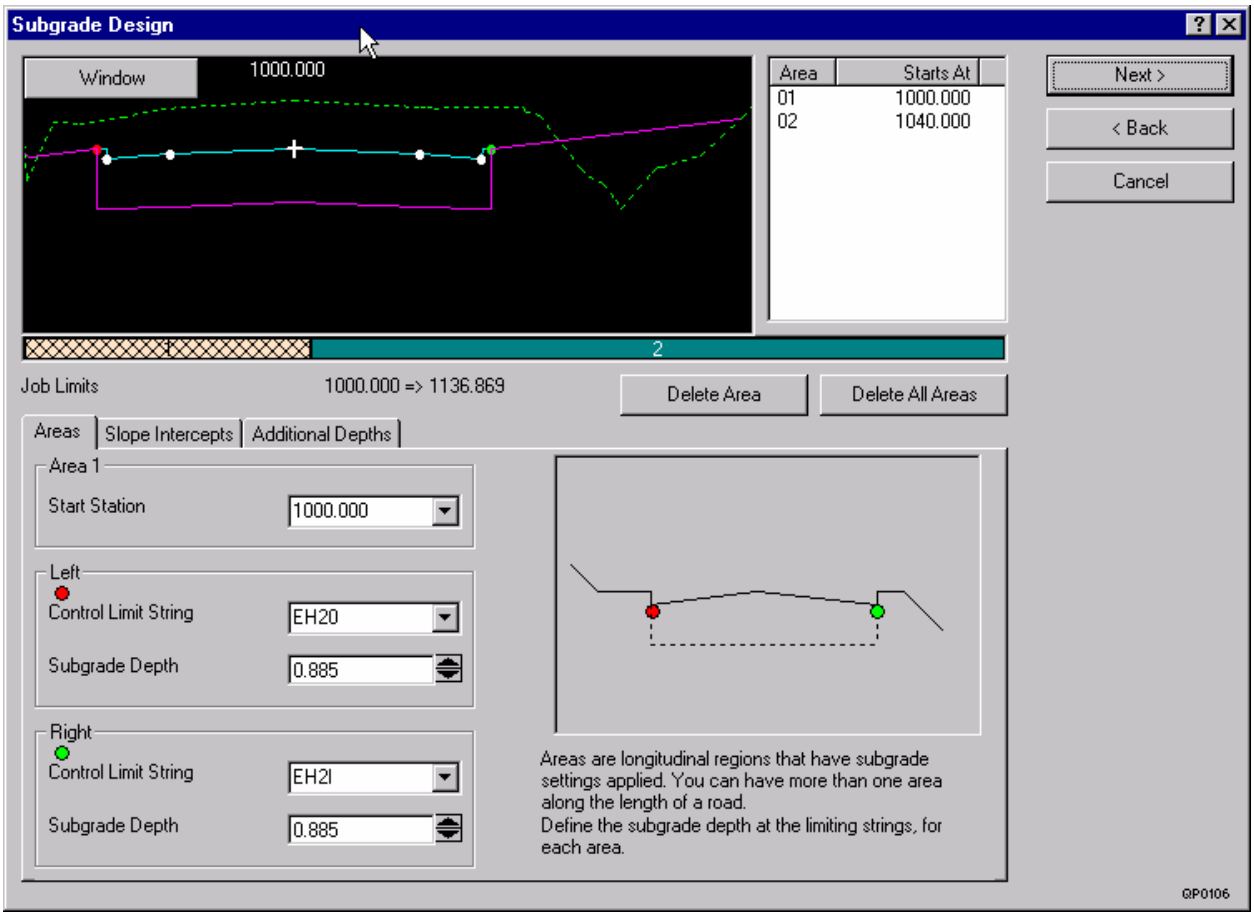
There are four major components to the Pavement and Subgrade Design Wizard:

Pavement Layer Design – This part allows you to apply a multi-layered pavement structure to a roadway. These pavement definitions can be used in the Volumetrics portion of the wizard to help define the volume of gravel base and subbase required. This process has not yet been developed but there is hope to do this at a later date describing its' use.
Subgrade Design – This is the portion of the wizard that will be described in depth for the remainder of this chapter.

Cross Section Working Drawings - If you have created pavement layers, this wizard will allow you to see a set of cross sections with these displayed on them, but they are not drawn in our standard MDOT format.

Reports - Not used.

Step 5: Click the Subgrade Design button to continue. After a short delay while MX processes some data, the following panel will appear:

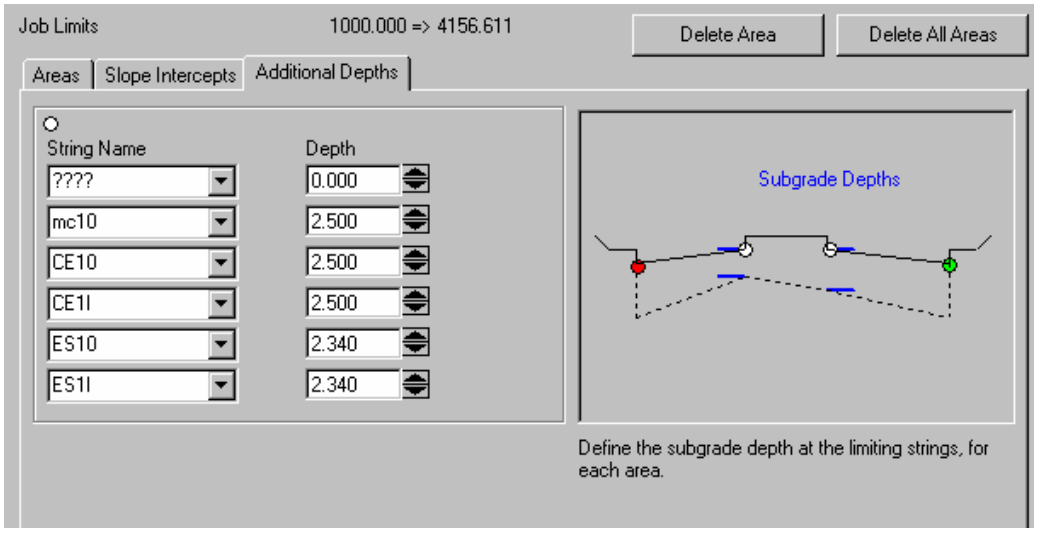


This is the basic subgrade design panel. In the example above, two areas have been defined as shown in the white box in the upper right-hand corner of the panel. The data for the first area is shown on the panel.

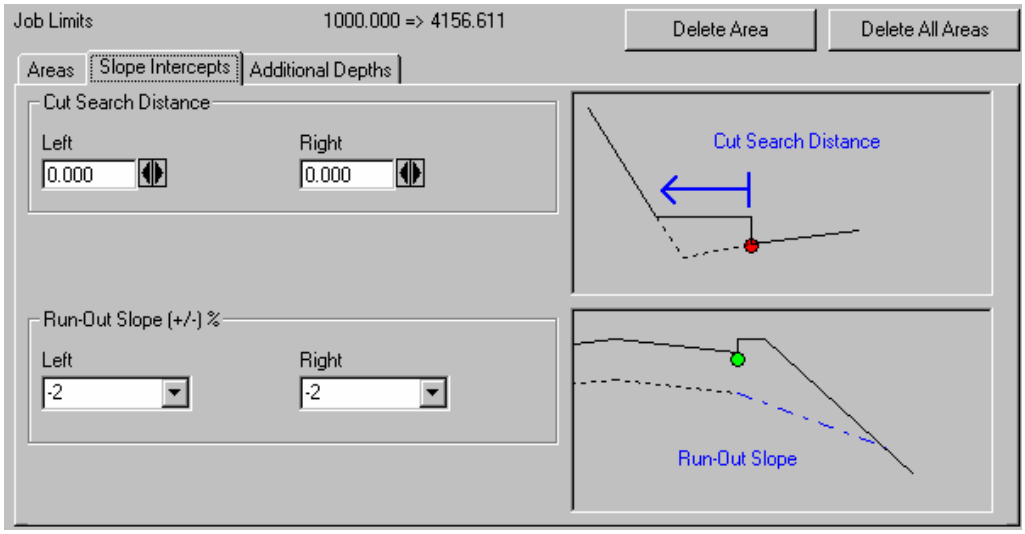
To Define Area 1:

- Select the start station of the area. In this example the start station is 10+00.
- Select the left and right control limit strings, and apply a subgrade depth. The left and right control limit strings are the outermost strings for which a defined depth will be provided. These control limit strings will most likely be the edge of shoulder (for day lighted sections), or The Earthworks Datum (EH) strings (for box sections) on your template. This is the point from which interfacing your subgrade to your template will begin. The wizard requires you to specify a depth at these locations, which is why the EH strings are required to create Box Sections. Notice in the panel that the left and right control limits are defined by the EH strings behind the curbs shown in the cross sections. These strings are 1 ft. beyond the gutter line. The tricky (and somewhat annoying) part is specifying the depths for the remaining strings between these limits.

- Click the Additional Depths tab, and list the strings from which you want to specify a fixed subgrade depth. The depths shown in the illustration below were based on a 2.5 ft. frost-free pavement structure. The curb used was type 3, mold 1. A table of depth values are provided for commonly-used shoulder widths and curb types at the end of this chapter for use with this wizard.



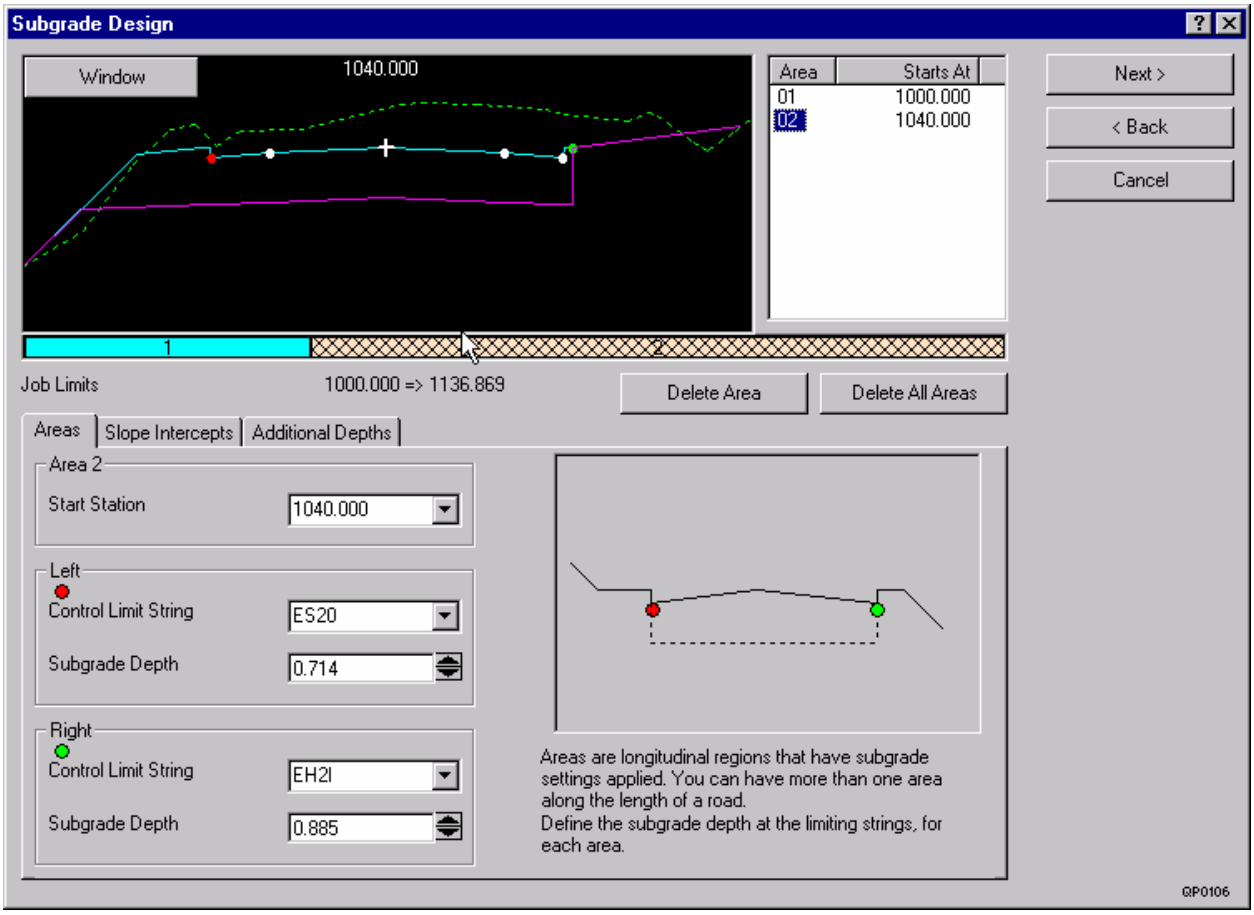
- Click the slope intercepts tab, and set the cut slope search distance and runout slope criteria. The cut slope search distance is the maximum distance that cut conditions (i.e. box section) will be attempted before applying the runout slope criteria. MDOT's standard subgrade design calls for a runout slope of -2%, so set both the left and right values to –2%.



NOTE: It appears that this part of the wizard is a bit buggy, particularly when it comes to applying the cut search criteria to define a box section. This will be illustrated and discussed a bit later in this chapter.

To define additional areas:

Simply return to the Areas Tab, and select a new Start Station value. The new area should be listed in the area list in the upper right hand corner of the panel.



In the example above, the new area starts at station 1+040. The reason this new area was necessary, is that this is the point on our alignment where our curb ends on the left side. Because the EH string on the left side doesn't exist beyond this point, we had to select a new left Control Limit String (ES20). As with Area 1, you should specify the Slope Intercept criteria, and any additional depths that are required.

Once you've finished defining your areas, click the NEXT button, and you'll see an animation progress through your sections with the subgrade criteria applied. Once this is complete, click Finish, your subgrade strings will be created, and you'll be returned to the Pavement and Subgrade Design: Options panel.

NOTE: A separate model is created to hold the subgrade strings from this wizard, and the model name is generated automatically. The subgrade model for an alignment will be called "SUBMODEL " + Name of model containing M-String + M-String Name.

i.e. if you create subgrade strings for an M-String named MC10 that resides in a model called DESIGN, the subgrade strings would be created in a model called

SUBMODEL DESIGNMC10